Forest Health Protection

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HAZARD RATING SYSTEM FOR MOUNTAIN PINE BEETLE IN LODGEPOLE PINE USING THE ORACLE DATABASE AND THE FOREST SERVICE IBM PLATFORM

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INTRODUCTION

The mountain pine beetle, Dendroctonus ponderosae Hopk., is a native bark beetle that can have major impacts on succession in ecosystems with lodgepole pine. Successful mountain pine beetle attacks kill lodgepole pine. The best strategy for minimizing tree mortality from the mountain pine beetle is prevention (Amman et al. 1977). Susceptible stands of lodgepole pine can be identified and managed to reduce landscape susceptibility prior to beetle-caused mortality. Mountain pine beetle epidemics in susceptible lodgepole stands tend to result in the mortality of a significant portion of the lodgepole component. In lodgepole-dominated forests, mountain pine beetle outbreaks may result in significant accumulations of fuels, the creation of large openings, and significant impacts on hydrologic function and wildlife habitat as well as the scenic quality of the landscape that may interfere with management objectives.

There are two stand level hazard rating systems frequently used to rate the susceptibility of lodgepole pine stands to the mountain pine beetle: Amman et al. 1977 and Shore and Safranyik 1992. The Amman system considers three stand factors in determining hazard--age, elevation, and diameter of lodgepole pine. The Shore and Safranyik system considers percentage of susceptible pine basal area, age, density, and location. Both systems evaluate individual stands and have not been automated to rate multiple stands across the landscape. After using both systems, we found that the Amman system tended to over estimate hazard, and that by incorporating stand basal area into the Shore and Safranyik system, we had a better representation of stand level hazards. We also found that inaccurate age data often gave us inaccurate hazard ratings.

In order to assess the potential for mountain pine beetles across a landscape, we developed a third hazard rating system which utilizes stand summary information to stratify stands into 14 hazard strata, which can then be aggregated into very low-, low,- moderate-, and high-hazard classes. This hazard rating system uses the stand characteristics in Shore and Safranyik and stand basal area. Age can be used or not with this system, depending on the manager's confidence in the accuracy of age information in the database. The system follows a step-wise progression to determine the appropriate hazard. The Region 1 National Forests have placed stand summary information (the Timber Stand Management Record System or TSMRS) into an Oracle database on the IBM system. Using Oracle's PL/SQL procedural language, we created a query that sequentially sorts stands into different hazard classifications, and which hazard rates all stands in a given ranger district at once, allowing for subsequent mapping of hazard across a landscape.

Hazard Rating

Hazard is the ability of a stand to support a growing population of mountain pine beetles. It is defined by two factors--the quality and the quantity of susceptible lodgepole pine. The quality of the lodgepole component of a stand as a mountain pine beetle food source is best characterized by stand density and phloem thickness. Since lodgepole pine phloem thickness is not measured in stand exams, diameter at breast height (d.b.h.),age, and other available stand characteristics are used as surrogates. The quantity of the food source refers to the species composition and density of the forest. A pure, well stocked lodgepole stand will be more likely to support a large mountain pine beetle population than a mixed species and/or poorly stocked stand.

The location of a stand also has a bearing on mountain pine beetle success. Lodgepole pine growing in cold, high-elevation areas is less likely to generate outbreak levels of mountain pine beetles because the beetle takes longer to complete its life cycle.

Hazard Rating Criteria

This hazard rating system follows a step-wise progression to determine hazard. A stand "falls out" at the first statement that describes its condition. Logic of this step-wise progression follows:

Mountain Pine Beetle in Lodgepole Pine Hazard Rating Logic

1. If % BA Lodgepole Pine = 0	Then Hazard = 0 - Extremely Low
2. If % BA Lodgepole Pine < 25%	Then Hazard = 1 - Low
3. If Stand BA <80 or >250	Then Hazard = 2 - Low
4. If # Tree per Acre > 3" d.b.h. < 100 or > 800	Then Hazard = 3 - Low
5. If Average d.b.h. Lodgepole Pine > 5" d.b.h. is < 6"	Then Hazard = 4 – Low
6.[1] If Subcompartment = ...	Then Hazard = 4.5 – Low
7.[2] If stand age <60	Then Hazard= 4.75 - Low
8. If % BA Lodgepole Pine is 25-50%	Then Hazard = 5 - Moderate
9. If Stand BA is 80-120	Then Hazard = 6 - Moderate
10. If # Trees per Acre > 3" d.b.h. 100-300 or 600-800	Then Hazard = 7 - Moderate
11. If Average d.b.h. Lodgepole Pine > 5" d.b.h. is <8"	Then Hazard = 8 - Moderate
12.[1] If Subcompartment = ...	Then Hazard = 9 - Moderate
13.[2] If stand age > or = 60 but <80	Then Hazard = 9.5- Moderate
12. Else	Then Hazard = 10 - High

[1]These clauses allow the incorporation of location into hazard calculation and require information from outside TSMRS. Elevation, Latitude, and Longitude are not included in TSMRS, but are available from other sources. The method to determine the location hazard factor can be found in Appendix 1.

[2]As programmed the mountain pine beetle hazard rating can be run with or without using age information.

Hazard Ratings and Landscape Level Assessments

The integration of Oracle databases and ArcView GIS software enables mapping of stands by their hazard rating on area maps. Hazard maps enable managers to identify concentrations of high- and moderate-hazard stands across a landscape. Adjacent high-hazard stands promote epidemic beetle populations by providing large areas of contiguous quality food. When high-hazard stands are surrounded by low-hazard stands, beetle populations are not as destructive. Low-hazard stands have lodgepole, but not of high enough quality or in large enough quantity to allow beetle populations to build to extremely destructive levels. Mountain pine beetle may still cause significant mortality in the lodgepole pine components of low-hazard stands in a landscape, but net losses will be lower than in a landscape where high-hazard stands are clustered.

Data Considerations

TSMRS data is stand summary data and is not as precise as stand exam data. TSMRS data summarizes stand information by diameter class and plurality species. Because data is summarized, if lodgepole pine is not the plurality (majority) species for a given diameter class, its presence may not be recognized and the assigned hazard rating may be artificially low. If lodgepole pine is the plurality species, but it is present in a mixed conifer stand where other species are present in appreciable levels, assigned hazard rating may be artificially high. Though hazard ratings for individual stands may be artificially high or low, the benefit of using TSMRS data is coverage. TSMRS data may be gathered through aerial photo interpretation and quick surveys which enable more stands to be hazard rated across a landscape.

When using hazard ratings in a landscape level analysis, it is assumed that stands contained in the TSMRS database are representative samples of landscape conditions. A number of stands may not be in TSMRS or have insufficient data for query processing. Prior to hazard rating, district personnel are strongly encouraged to carefully look at the rated stands to judge how well this assumption is met.

Hazard rating assumes stands are homogeneous. If there is variability within the stand in any of the parameters used to determine hazard, the system is unable to detect it and adjust the hazard accordingly.

This system provides the user with printouts of stand characteristics. No attempts have been made to "grow" stands from the date of the exam to the current date. It is important to consider the age of the data when interpreting hazard. Many of the characteristics of the stand used in hazard determination may have changed since the time of the exam. As always, it is prudent to ground check results.

Appropriate Use of Hazard Map

Hazard maps produced from data from the query are powerful tools for managers and planners at the geographic area assessment level. Such maps help managers identify those areas that have the highest probability of significant mountain pine beetle mortality.

Although hazard rating does not predict when mountain pine beetle will be active in a certain stand, experience has shown that beetles will eventually infest high-hazard stands.

Hazard rating does not predict stand losses from mountain pine beetles. Hazard ratings address the quality and quantity of food available to the beetle, but does not address beetle populations. In order to address loss, it is necessary to collect additional data about beetle populations at the stand level and run a loss prediction model such as the insect and disease detection survey (INDIDS) (Bousefield 1980) or pest extensions to the forest vegetation simulator.

Project Planning

A hazard map is the easiest way for managers to quickly identify areas with a high quantity of quality food for the mountain pine beetle, thus the areas most likely to experience significant mountain pine beetle impacts. More information is needed to plan projects.

At most project levels the assumption that stands are homogeneous may no longer be appropriate. Additional information from a variety of sources, including recent walk throughs, aerial photography, insect aerial detection surveys and models runs (INDIDS and the mountain pine beetles extension of the Forest Vegetation Simulator) should be gathered to help determine which stands are most critical for treatment. The manager should also consider the current level of beetle pressure in the area. Beetle pressure is the magnitude of a mountain pine beetle population affecting a stand as determined by the number of currently infested trees and their proximity to the stand being assessed. Beetle pressure is a dynamic variable and may change quite suddenly due to factors such as adverse or favorable weather conditions, or immigration of beetles from another location. For this reason the beetle pressure should be reviewed every year or two.

Ways to Alter Hazard: Management Considerations

Hazard can be altered through silvicultural practices that break up the large, homogeneous, susceptible forest types that historically hosted major mountain pine beetle

epidemics. These include thinning susceptible stands, regeneration harvests, stand replacement fire, and stocking control in young stands. Reducing the ratio of large-diameter pine to other size and species components by thinning "from above" will reduce the hazard of the stand by reducing the relative abundance of susceptible pine, possibly reducing the average age of the pine component of the stand, and by lowering stand density. This approach is perhaps best suited to mixed stands where species other than pine could be left and would respond well to overstory removal provided the other species in the stands do not have other insect and disease considerations (for example root disease in Douglas and true firs). In pure pine stands, removal of the larger pines could result in "high-grading," leaving inferior trees that will produce a poor stand. Also, the residual, smaller diameter pine are susceptible to wind and snow breakage. Through stocking control in young stands and partial cutting in older stands, densities can be lowered below 100 stems per acre to reduce stand hazard. At these lower densities, larger and older pines can be left standing and the susceptibility will be relatively low.

Low-hazard stands are not likely to support epidemic beetle populations. In a landscape composed of mostly low-hazard stands, the manager may want to consider leaving beetle populations alone. In lower hazard stands beetles often act as thinning agents, naturally lowering density and increasing the vigor of the remaining trees. Low-hazard stands do not have both high quality and quantity of food so mountain pine beetle losses in any one year are not likely to be overwhelming. The beetles will "pick away" at the pine component of these stands until there are no more highly susceptible trees. The residual stand will likely have a lodgepole component that is better off from the thinning provided by the beetle.

Conclusion

The use of landscape hazard maps for mountain pine beetle in lodgepole pine will assist managers in determining the potential for beetle outbreaks to interfere with management objectives. By identifying high-hazard stands prior to beetle outbreaks, managers have an opportunity to reduce hazard through silvicultural prescriptions, including prescribed fire, or to determine if action would be warranted. By producing landscape level hazard maps prior to significant beetle activity, managers are able to be proactive in addressing beetle dynamics across a landscape by altering hazard conditions instead of reacting to beetle activity.

Literature Cited

Amman, G.D., Mark D. McGregor, Donn B. Cahill, and William H. Klein. 1977. Guidelines for reducing losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the Rocky Mountains. USDA Forest Service General Technical Report INT-36.

Shore, T. and L. Safranyik. 1992. Susceptibility and risk rating system for the mountain pine beetle in lodgepole pine stands. Forestry Canada BC-X-336

Appendix 1: How to Incorporate Location in the Mountain Pine Beetle Hazard Rating System

Location is an important consideration when determining the susceptibility of a lodgepole pine stand to mountain pine beetle activity. A stand's location in terms of latitude, longitude, and elevation in large part describes the climate in the stand. As climate becomes more severe, beetle development is prolonged. The longer it takes beetles to complete development, the more likely they will die before reproducing. Stands with locations unfavorable to beetle development are less likely to suffer excessive beetle-caused mortality.

Location Calculation for the IBM Mountain Pine Beetle Hazard Rating System

When the mountain pine beetle system is initiated on the IBM platform, the user is asked for subcompartment numbers within the analysis areas which fall into low and moderate location categories. To determine if a subcompartment falls into a moderate or low category, the following information is necessary:

1. The latitude of the subcompartment (degrees/ minutes),
2. The longitude of the subcompartment (degrees/ minutes), and
3. The average elevation of the subcompartment (in meters).

Once these values are obtained, latitude and longitude values need to beconverted from degrees/ minutes into degrees and tenths of degrees: for example 115 degrees 15 minutes would be converted to 115.25.

Location = Low if the elevation in meters is greater than (24.4 x longitude) - (121.9 x latitude) + 5045.1

Location = **Moderate** if the elevation in meters is greater than **(24.4 x longitude) – (121.9 x latitude) + 4545.1** but less than the Low value.

If the average elevation of a subcompartment in meters is not greater than the moderate threshold, then the location is considered to be adequate for normal beetle development in most years.

Conversion Fators

1 meter = 3.281 feet

An increase of 15 feet in latitude, longitude constant, is the same as an increase of 30.48 meters (100 feet) in elevation.

An increase of 15 feet in longitude, latitude constant, is the same as an increase of 6.09 meters (20 feet) in elevation.